Two Demarcation Problems In Ontology

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Abstract

In this paper I will attempt to characterise the difference between ontological and non-ontological categories for the sake of a better understanding of the subject matter of ontology. My account of ontological categories defines them as equivalence classes of a certain family of equivalence relations that are determined by ontological relations. As a result, the demarcation problem for ontological categories turns out to be dependent on the demarcation problem for ontological relations.

Introduction

There are a lot of ontologies out there. (Ding et al., 2005) claim to harvest from the Internet more than 300 000 Semantic Web documents, of which 1.5% may be unique ontologies. But wait! Are you really willing to consider the so-called ontology of Bibtex entries (`http://zeitkunst.org/bibtex/0.2/bibtex.owl`) or the so-called ontology of the Catholic Church administration (Garbacz et al., 2010) as genuine ontologies? Or when someone creates his or her first, 'Hello, world', OWL ontology in Protege with three classes and one object property, will you call the result a (real) ontology?

Some of these so-called ontologies may be considered faulty on the basis of their immaturity: some categories or relations of theirs may be claimed to be underspecified - for instance because of the expressivity constraints of the formal framework adopted – like OWL. Another reason may be the inappropriate level of generality. After all, applied ontology cannot pretend to cover all categories or concepts, i.e., some of them are out of the scope. Since applied ontology seems to inherit the pretence for maximal generality from its predecessor, philosophical ontology, there must exist a kind of cut-off point, or a cut-off zone with possibly vague boundaries, that would demarcate the proper subject matter of applied ontology from the subject matters of other disciplines. For example, given the (long) history of philosophical ontology and the short timespan of applied ontology it seems reasonable to expect from an applied ontologist to build a formal theory of endurants or properties but not a formal theory of tree ferns. The latter are simply too specific to fit his or her research interests. Or if not, then everything goes into the scope.

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This paper is then about the *proper* subject matter of applied ontology. I will attempt to draw a demarcation line between ontological and non-ontological categories. To this end I will search for the proper level of generality of the latter by looking at how philosophical ontology defines its subject matter. I will discuss a number of attempts to capture the specific nature of the ontological categories, as they are used in philosophy, and on the basis of this survey I outline my own proposal. The main point of my contribution is the idea that ontological categories are the most general categories that cut the reality at its joints, where cutting is provided by ontological relations. In consequence it will turn out that this account depends on how one can draw a demarcation line between ontological and non-ontological relations.

Ontological categories in philosophical metaontology

So there is philosophy, one of which distinct features is the set of terms or categories it employs, e.g., "being", "causality", "emergence", etc. Some of them originated outside philosophy and sometimes persist in parallel discourses, others were invented by and for philosophers and rarely are used elsewhere.

And there is ontology, which from its very beginning was considered as (one of) the most abstract branch in philosophy. So it seems that such categories as "substance" or "perdurant" are among the most promising candidates for ontological investigations. Other categories, such as "obligation", while remaining within the scope of philosophy, are too specific for ontology itself. There are also other terms like "location" or "function" that seem to borderline cases of ontological notions. Obviously, much depends on a particular system of or trend in philosophy, so one category be ontological for one system but not for the other.

Then the question arises whether there exists some kind of reason or rationale for distinguishing ontology among other philosophical disciplines. Obviously, the rationale may be purely historical, i.e., we may report that such and such regarded a given list of terms as ontological or not. If the philosopher in question happened to be an influential figure in history of philosophy, his or her list of terms may be shared by other fellow philosophers. Although this kind of research is indispensable, a purely historical account is not, in my opinion, fully satisfactory.

There seems to be four main types of philosophical accounts of ontological categories that provides such rationale – cf. (Westerhoff, 2005, p. 22-64): 1. universalist 2. substitutional 3. identity-based 4. modal.Each account attempts to specify sufficient and/or necessary conditions for a category to be an ontological category.

In a *universalist* account an ontological category is any most general category of things there are. For instance, (Norton, 1976) propounds that an ontological category is any natural category that is directly subsumed by the universal category. A more recent attempt along these lines can be found in (van Inwagen, 2012).

The *substitutional* approach defines ontological categories as equivalence classes by means of a specific type of substitution, where the latter may operate either within the linguistic or the ontic structures. As for the former suppose that entities x and y are represented by two expressions (e.g., nouns, nominal phrases, sentences, etc.) α and β. Consider a set of linguistic structures, usually sentences, in which, α occurs. The set in question is assumed to contain all and only those structures that exhibit some salient linguistic feature, e.g., they are grammatical or meaningful. If for each (or some) element ϕ of this set, when you can swap α with β, you will get a linguistic structure with the same feature, then x is claimed to belong to the same category as y. F. Sommers showed in a series of papers how this idea may be fleshed out - see (Sommers, 1959), (Sommers, 1963), (Sommers, 1971). The other type of substitutional approach is quite unique in philosophy – I am aware only of (Westerhoff, 2005), who employed the notion of substitution over the ontic structures: instead of replacing words and phrases in sentences, (Westerhoff, 2005) shows that we can replace components of states of affairs in order to get the equivalence classes playing the role of ontological categories.

An *identity-based* account defines ontological categories in terms of the identity criteria. For instance, (Dummett, 1973, p. 73-76) defines ontological categories as the most general categories whose instances have the same criterion of identity. That is to say, he considers classes of proper nouns such that each noun in a class has the same criterion of identity - the example of such class contains 'man', 'tailor', 'coward', etc. Then he holds that in each such class there is the most general noun, e.g., 'person' or 'animal' in the case of the class in question, and this noun is claimed to express an ontological category. One can argue that this type is also exemplified in the formal theory of properties developed by N. Guarino, Ch. Welty and others under the label of OntoClean - see, for example, (Guarino and Welty, 2000), (Guarino and Welty, 2002), (Guarino, 2009). Although it is not focused on the notion of ontological category *per se*, this approach illustrates that besides criteria of identity also other ontological aspects may be taken into account when characterising the ontological research, mainly modalities and the relation of ontological dependence. In this sense it can be an instance of the fourth type as well.

A *modal* account finds the specificity of ontological categories in their modal status. For example, using the OntoClean terminology ontological categories may be identified with rigid properties, i.e., if a property is essential for its instances, it is (or corresponds to) an ontological category.

Are these accounts satisfactory? Obviously, even a cursory evaluation of the most prominent of them is beyond the scope of this paper, but this question reveals that in order to answer it we should provide some kind of the adequacy criteria for theories of ontological categories. (Westerhoff, 2005, p. 22-64) is the only known to me attempt to list such constraints. His account amounts to the claim that a conception of ontological categories is *adequate* only if it defines a non-empty, but finite, set of ontological categories such that

1. it allows for the fact that some categories are not ontological;
2. some ontological categories may subsume others;
3. no ontological category (properly) overlaps any other.

On top of this formal criteria J. Westerhoff seems to assume that an adequate account will not propound categories that are much more specific than the categories we know from the history of philosophy.

How do the above accounts score against such requirements? (Westerhoff, 2005, p. 22-64) raises the following concerns:

1. universalist accounts are unable to define a non-arbitrary cut-off point:
   (a) either they stop at the very first level, i.e., they provide a flat list of ontological categories such that neither of them subsumes or is subsumed by others - as it is the case with (Norton, 1976),
   (b) or they do not set the cut-off point at all - this may be the problem with (van Inwagen, 2012),
   (c) or they could set up an, ontologically arbitrary, cut-off point, e.g., at the level of the most general scientific categories; see, for instance, (Schwarz and Smith, 2008, p. 224).
2. substitutional accounts tend to generate too specific or ontologically odd categories, e.g., the category of buildings because of the predicate "has the green back doors" – this is a consequence of their dependence on the nitty-gritty details of the lexicon and grammar of ethnic languages;[1]
3. identity-based account, or to be more specific, the account from (Dummett, 1973, p. 73-76) provides only a flat list of ontological categories; moreover it should be noted that they are vulnerable to the various controversies pertinent to the notion of identity criteria – see, e.g., (Carrara and Giaretta, 2004);
4. modal accounts are too "generous": such categories as mammals, vertebrates or chordates are rigid, but they do not look very ontological (in the sense of philosophical ontology at least) – the cut-off point is set too far down the subsumption hierarchy.

[1]Westerhoff, or course, believes that this issues does not concern his own theory, but the lack of space prevents me from explaining the intricacies of his approach.

The mixed accounts may fare better, but a general evaluation of them is clearly impossible. As for OntoClean, it seems that none of the 12 types of properties classified in (Guarino, 2009) may be identified with ontological categories. Consider the two top-most types: sortals and non-sortals. Some ontological categories, like the top-most category of being, are non-sortals, while others, like persons are sortals. On the other hand, due to their generality, most of the examples of ontological categories we know from history of ontology are rigid.

Towards a new perspective on ontological categories

Reflecting on the four types of accounts discussed in the previous section you may notice that each account groups entities with respect to a particular ontological aspect of these entities and builds the definition of category around this aspect: generality, identity, and modality. If we consider the actual history of ontology, one aspect that is clearly missing here is existence or rather mode of existence. As one can stipulate that a single ontological category collects entities with the same criterion (or criteria) of identity, one can also stipulate that ontological categories should be defined with respect to the mode of existence: two entities belong to one ontological category if they exist in the same way. Obviously, when properly developed, this characteristics can be seen as, at best, only a partial account of what ontological categories are because it focuses on their existential dimension, so to speak, ignoring other relevant features, e.g., the modal status. In other words, this characteristics may be taken as a definition of existential ontological categories.

x belongs to the same existential ontological category as y iff x exists in the same way as y.

Then, existential ontological categories may be defined as the equivalence classes of the relation 'exists in the same way as'. For the sake of simplicity, "existential ontological category" will be sometimes abbreviated to "ontological category" later on within this section.

Now the question arises when two entities share the same mode of existence. In what follows I will examine one possible answer to this question: two entities exist in the same way if they depend on entities from the same ontological categories.[2]

x exists in the same way as y iff x depends on the same existential ontological categories as y.

Note that we cannot claim that two entities exist in the same way only if they depend on entities from the same categories *simpliciter* because the latter may be too specific to characterise the relatively abstract notion of mode of existence. For instance, suppose that you want to characterise the way in which colours, or qualities in general, exist. If you claimed that two colours exists in the same way only if they depend on entities from the same categories, then the colour of this rose and the colour of that telephone box will exist in different ways provided that colours depend in their existence on their bearers (e.g., on roses and telephone boxes).

Putting these two claims together we get:

x belongs to the same existential ontological category as y iff x depends on the same existential ontological categories as y.

Of course, this characterisation is circular, so it cannot be considered as a *simple definition* of ontological categories. However, it is not viciously circular, so it may serve to separate ontological categories from non-ontological ones. In what follows I will try to flesh out this idea in more rigorous way.

Suppose that there is given a discourse or a body of knowledge that employs a certain set $\mathfrak{C}$ of categories: $\mathtt{C}_1, \mathtt{C}_2, \ldots$: ontological and/or non-ontological. As far as $\mathtt{C}_1, \mathtt{C}_2, \ldots$ are concerned, it is assumed that each entity from the domain, say some $\mathtt{x}$, either falls under some category $\mathtt{C}$ (written as: $\mathtt{Inst}(\mathtt{C}, \mathtt{x})$) or not - without any temporal or modal qualifications.[3] I will make no assumptions on the formal properties of this relation. In particular, I do not assume that it is extensional, so there might be two different categories with the same extension. Therefore, it is useful to introduce the auxiliary notion of category extension:

$$\mathtt{ext}(C) \triangleq \{x : \mathtt{Inst}(C, x)\}. \qquad (1)$$

Suppose that there is given a binary predicate "$\mathtt{dep}$" to refer to the relation of ontological dependence between the entities from its domain. Again I make no specific assumptions about the formal properties of this relation except for the following: if $\mathtt{dep}(x, y)$, then it is necessary that $\mathtt{dep}(x, y)$.

Let me start with the auxiliary definition of dependence between objects and ontological categories:

$$\mathtt{deP}(x, C) \triangleq \exists y[\mathtt{dep}(x, y) \wedge \mathtt{Inst}(C, y)]. \qquad (2)$$

We can now define the equivalence relation that sorts out the entities with respect to the categories on which they depend:

$$x =_{\mathtt{dep}} y \triangleq \forall C[\mathtt{deP}(x, C) \equiv \mathtt{deP}(y, C)]. \qquad (3)$$

Intuitively, $[x]_{\mathtt{dep}}$, i.e., the equivalence class of x with respect to $=_{\mathtt{dep}}$, may be seen as a formal representation of the way (mode) of x's existence. In other words, any two entities from $[x]_{\mathtt{dep}}$ are claimed to exist in the same way.

[2] The idea that the relation of dependence can be employed as a means to define ontological categories is by no means new. For instance, (Thomasson, 1999, p. 115-136) sketches a landscape of ontological categories defined in terms of her six kinds of ontological dependence. The main difference between her definitions and the account developed here is that I attempt to build a formal account to distinguish ontological categories from other categories within a certain body of knowledge.

[3] Although I find the modal accounts of ontological categories inadequate, it seems unlikely that an entity may change its ontological category over time (or "over" possible worlds). The reason is the historical fact that ontological categories are highly abstract. So perhaps x can stop being a dog without ceasing to exist (which I find problematic). But if x is a substance, process, or boundary at time t, then for each other time at which x exists, x is still a substance, process, or boundary. Therefore, I did not find it necessary to relativise the notion of instantiation to times or possible worlds.

Now if ways of existence provide the necessary and sufficient conditions for ontological categories, the following condition needs to be introduced:

$$\forall C \exists x \; \mathtt{ext}(C) = [x]_{\mathsf{dep}}. \tag{4}$$

So the extension of each category is a set of entities with the same mode of existence if we construe the former along the lines of definition 3. In order to account for the usual assumption that ontology covers the whole realm of being, we also need to guarantee that the collection of ontological categories covers the whole domain:

$$\forall x \exists C \; \mathtt{Inst}(C, x). \tag{5}$$

Note that this condition is equivalent to 6 provided that 4 is taken for granted:

$$\forall x \exists C \; \mathtt{ext}(C) = [x]_{\mathsf{dep}}. \tag{6}$$

A finite, non-empty set $\mathfrak{C}$ of categories is a *set of (existential) ontological categories* if it satisfies conditions 4 and 5.

To illustrate ho such framework may function consider a first-order formal theory with a signature that contains the following predicates:

1. Ent as a unary predicate, which is intended to represent the universal category;
2. Obj, Per, End, Pro, Soa as unary predicates, which are intended to represent, respectively, the categories of objects, perdurants, endurants, properties, and states of affairs;
3. $\mathtt{dep}$.

Suppose that the theory in question includes the following theses:[4]

$$\forall x \mathsf{Ent}(x). \tag{7}$$
$$\forall x[\mathsf{Ent}(x) \equiv \mathsf{Obj}(s) \veebar \mathsf{Pro}(x) \veebar \mathsf{Soa}(x)] \tag{8}$$
$$\forall x[\mathsf{Obj}(x) \equiv \mathsf{End}(x) \veebar \mathsf{Per}(x)] \tag{9}$$
$$\forall x[\mathsf{Obj}(x) \to \neg\exists y \mathsf{dep}(x,y)] \tag{10}$$
$$\forall x[\mathsf{Pro}(x) \to \exists y(\mathsf{Obj}(y) \wedge \mathsf{dep}(x,y))] \tag{11}$$
$$\forall x,y[\mathsf{Pro}(x) \wedge \mathsf{dep}(x,y) \to \mathsf{Obj}(y)] \tag{12}$$
$$\forall x\{\mathsf{Sa}(x) \to \exists y,z[(\mathsf{Obj}(y) \wedge \mathsf{dep}(x,y)) \wedge (\mathsf{Pro}(z) \wedge \mathsf{dep}(x,z)]\} \tag{13}$$
$$\forall x,y\{\mathsf{Sa}(x) \wedge \mathsf{dep}(x,y) \to [(\mathsf{Obj}(y) \vee \mathsf{Pro}(y)]\} \tag{14}$$

Informally, there are objects, properties, and states of affairs. An object may be either an endurant or a perdurant. Properties depend on objects (and only on objects) and objects do not depend on anything. States of affairs depend both on objects and on properties (and only on them).

By the above account

1. the empty set represents the way in which objects exist,
2. the set of objects represents the way in which properties exist,
3. the set of objects and the set of properties represent the way in which states of affairs exist.

As a result, in this theory:

1. objects (Obj), properties (Pro), and states of affairs (Soa) are ontological categories;
2. endurants (End) and perdurants (Per) are not (existential!) ontological categories because they are too specific, i.e., they both exist in the same way;
3. entities (Ent) are not ontological categories because it is too general, i.e., its instances exhibit two different ways of existence.

Note however that when we slightly modify the following theory by removing Obj from its signature, the universal category of entities becomes the only ontological category. Suppose that the theory in question includes now the following theses:

$$\forall x \mathsf{Ent}(x) \tag{15}$$
$$\forall x[\mathsf{Ent}(x) \equiv \mathsf{End}(x) \veebar \mathsf{Per}(x) \veebar \mathsf{Pro}(x) \veebar \mathsf{Sa}(x)] \tag{16}$$
$$\forall x[\mathsf{End}(x) \to \neg\exists y \mathsf{dep}(x,y)] \tag{17}$$
$$\forall x[\mathsf{Per}(x) \to \neg\exists y \mathsf{dep}(x,y)] \tag{18}$$
$$\forall x[\mathsf{Pro}(x) \to \exists y[(\mathsf{End}(y) \vee \mathsf{Per}(y)) \wedge \mathsf{dep}(x,y))] \tag{19}$$
$$\forall x,y[\mathsf{Pro}(x) \wedge \mathsf{dep}(x,y) \to \mathsf{End}(y) \vee \mathsf{Per}(y)] \tag{20}$$
$$\forall x\{\mathsf{Sa}(x) \to \exists y,z[(\mathsf{End}(y) \vee \mathsf{Per}(y) \wedge \mathsf{dep}(x,y) \wedge \mathsf{Pro}(z) \wedge \mathsf{dep}(x,z)]\} \tag{21}$$
$$\forall x,y\{\mathsf{Sa}(x) \wedge \mathsf{dep}(x,y) \to [\mathsf{End}(y) \vee \mathsf{Per}(y) \vee \mathsf{Pro}(y)]\} \tag{22}$$

Now endurants and perdurants do not qualify as ontological categories for the same reason as before. The category of properties is not an ontological category. Assume it were. Then its mode of existence would be represented by the same categories as the the mode of existence of states of affairs and this would violate condition 4. For the same reason the category of states of affairs is not an ontological category. On the other hand, the category of entities (Ent) qualifies for this status: it represents its own mode of existence since there are no other, more specific, categories.

Of course, not every body of knowledge or a formal theory is doomed to have its set of ontological categories. For example, if we strip our toy example even further by taking out predicate Ent, then we will get a theory without ontological categories.

It can be shown that for each set of categories conditions 4 and 5 (together with the auxiliary definitions) allow for at most one set of ontological categories – up to the extensional equivalence of categories:

Fact 1. *If* $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ *and* $\{\mathsf{E}_1, \mathsf{E}_2, \ldots\}$ *are sets of ontological categories, then*

1. *for each category D_i there exists category E_j such that* $\mathtt{ext}(D_i) = \mathtt{ext}(E_j)$,
2. *for each category E_i there exists category D_j such that* $\mathtt{ext}(E_i) = \mathtt{ext}(D_j)$.

Proof. Assume otherwise. Let $\mathsf{D_i}$ and $\mathsf{E_j}$ be two extensionally different categories, i.e., $\mathtt{ext}(\mathsf{D_i}) \neq \mathtt{ext}(\mathsf{E_j})$. Due to 5 there must exist at least one such pair of extensionally different categories that $\mathtt{ext}(\mathsf{D_i}) \cap \mathtt{ext}(\mathsf{E_j}) \neq \emptyset$. So let x belong to both extensions. Now because $\mathsf{D_i}$ and $\mathsf{E_j}$ are ontological categories condition 4 implies that there are y and z such that $\mathtt{ext}(\mathsf{D_i}) = [\mathsf{y}]_{\mathsf{dep}}$ and $\mathtt{ext}(\mathsf{E_j}) = [\mathsf{z}]_{\mathsf{dep}}$. Then by definition 2, $\forall C[\mathtt{deP}(\mathsf{x}, C) \equiv \mathtt{deP}(\mathsf{y}, C)]$ and $\forall C[\mathtt{deP}(\mathsf{x}, C) \equiv$

[4] '$\veebar$' stands for exclusive disjunction.

$\mathtt{deP}(\mathsf{z}, C)]$. Thus $\forall C[\mathtt{deP}(\mathsf{y}, C) \equiv \mathtt{deP}(\mathsf{z}, C)]$, so $[\mathsf{y}]_{\mathsf{dep}} = [\mathsf{z}]_{\mathsf{dep}}$ and $\mathtt{ext}(\mathsf{D_i}) = \mathtt{ext}(\mathsf{E_j})$. □

Finally, let me note that the account defined in this section (schema 4 and condition 5) satisfies all aforementioned formal constraints from (Westerhoff, 2005, p. 22-64) except for 2 - the (existential) ontological categories always form a flat list with no hierarchy.

To wrap up, although the above characteristic of ontological categories is circular, in certain cases it may produce unambiguous results, which are partially adequate to an intuitive understanding of ontology one might have.

The perspective generalised

Needless to say, the account defined by conditions 4 and 5 is by no means satisfactory as an account of all ontological categories, for instance, we saw that it may be incapable to capture the ontologically important distinction between endurants and perdurants. So let me explain how it can be generalised.

Consider again the set $\mathfrak{C}$ of categories: $\mathsf{C}_1, \mathsf{C}_2, \ldots$. Assume that there is a finite set of binary ontological relations: $\mathsf{r}_1, \mathsf{r}_2, \ldots, \mathsf{r}_n$[5] – one of them may be the relation of existential dependence. This seems to me a crucial assumption in my account and I will get back to it in the next section – for now suppose that we can somehow know which relations are ontological and which are not.

Auxiliary definition 2 will be now replaced with two definitions

$$\mathtt{dom}(r, 1, x, C) \triangleq \exists y[r(x, y) \wedge \mathtt{Inst}(C, y)]. \quad (23)$$

$$\mathtt{dom}(r, 2, x, C) \triangleq \exists y[r(y, x) \wedge \mathtt{Inst}(C, y)]. \quad (24)$$

'$\mathtt{dom}(r, 1, x, C)$' is to mean that x as a member of the domain of relation r is related by this relation to some member y of category C. Definition 23 amounts to 2 when r is $\mathtt{dep}$: $\mathtt{deP}(x, C) \equiv \mathtt{dom}(\mathtt{dep}, 1, x, C)$. '$\mathtt{dom}(r, 2, x, C)$' is to be understood in the analogous way.

For each relation we can now define two equivalence relations, both of which to be captured by the same definitional schema:

$$x =_{<r,m>} y \triangleq \forall C[\mathtt{dom}(r, m, x, C) \equiv \mathtt{dom}(r, m, y, C)], \quad (25)$$

where m ranges over all natural numbers from 1 up to the arity of relation r.

Now if $x =_{<r,1>} y$, this is to mean that x and y happen to be related by relation r to entities from the same categories. $x =_{<r,2>} y$ is to be understood in the analogous way. Incidentally, when r is symmetric, $x =_{<r,1>} y \equiv x =_{<r,2>} y$.

Finally, '$=_r$' is to denote the product of all such equivalence relations $_{<r,m>}$ - in our case the product of $_{<r,1>}$ and $_{<r,2>}$:

$$x =_r y \triangleq \forall m\, x =_{<r,m>} y. \quad (26)$$

[5]For the sake of simplicity, I restrict the scope of my account to binary relations. As far as I can see it does not affect its generality. I hope that extending this account for the relations with arbitrary arities should be straightforward.

In the previous section "$x =_{\mathtt{dep}} y$" was claimed to characterise the mode of existence (of x and y). Now "$x =_r y$", its generalisation, may be claimed to characterise this ontologically salient aspect that is determined by relation r.

For instance, consider a relation of participation, $\mathtt{part}$, such that $\mathtt{part}(x, y)$ means that x participates in (the whole of) y. Suppose again that End and Per are among categories $\mathsf{C}_1, \mathsf{C}_2, \ldots$ and are such that

$$\forall x,y[\mathtt{part}(x,y) \rightarrow \mathsf{End}(x) \wedge \mathsf{Per}(y)]. \quad (27)$$

$$\forall x[\mathsf{End}(x) \rightarrow \exists y\ \mathtt{part}(x,y)]. \quad (28)$$

$$\forall x[\mathsf{Per}(y) \rightarrow \exists y\ \mathtt{part}(y,x)]. \quad (29)$$

Then the quotient set of "$=_{\mathtt{part}}$" has three equivalence classes:

1. $\{x : \exists y\ \mathtt{part}(x, y)\}$
2. $\{x : \exists y\ \mathtt{part}(y, x)\}$
3. $\{x : \neg\exists y[\mathtt{part}(x, y) \vee \mathtt{part}(y, x)]\}$

The first two classes are extensions of End and Per and these two may be claimed to characterise this ontologically salient aspect that is determined by '$\mathtt{part}$'. The third equivalence class is a kind of the recycle bin for the participation relation. Every entity that is not involved in this relation ends up there, so the ontological significance of any category whose extension is equal to this class seems to be minor.

Each ontological relation gives rise to a quotient set whose members will be taken as the extensions of our ontological categories. As a result, we get a faceted classification, where each facet is a set of ontological categories determined by, via 26, an ontological relation – for the notion of faceted classification see, for instance, (Mills, 2004).

One may now consider any relation $\mathsf{r_i}$ and its corresponding constraint on ontological categories:

$$\forall C \exists x\ \mathtt{ext}(C) = [x]_{\mathsf{r_i}}. \quad (30)$$

Since the proof of Fact 1 did not make any assumptions about the properties of $\mathtt{dep}$ we can generalise it to establish Fact 2:

Fact 2. *If* $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ *and* $\{\mathsf{E}_1, \mathsf{E}_2, \ldots\}$ *are sets of ontological categories, then*

1. *for each category D_i there exists category E_j such that* $\mathtt{ext}(D_i) = \mathtt{ext}(E_j)$,
2. *for each category E_i there exists category D_j such that* $\mathtt{ext}(E_i) = \mathtt{ext}(D_j)$.

Combining such sets of ontological categories, i.e., taking products of equivalence classes from different quotient sets, we could get the extensions of more specific ontological categories. Probably the simplest way to account for that possibility is to replace previous condition 4 with the "condition schema":

$$\forall C \exists r_1, r_2, \ldots, r_k \exists x\ \mathtt{ext}(C) = \prod_{i=1}^{k} [x]_{r_i}, \quad (31)$$

where $1 \leq k \leq n$ and "$\prod_{i=1}^{k}$" stands for the k-ary intersection of sets.

As before, in order to account for the universality of the collection of ontological categories, I assume condition 32:

$$\forall r \forall x \exists C \ \mathtt{ext}(C) = [x]_r. \tag{32}$$

A finite, non-empty set $\mathfrak{C}$ of categories is a *set of ontological categories* (with respect to a set of ontological relations: $\mathsf{r}_1, \mathsf{r}_2, \ldots, \mathsf{r}_n$) if both sets satisfy condition 32 and one or more conditions that fall under schema 31.

To illustrate how such framework may function I will supplement the first example discussed in the previous section with the example from this section. In other words, let me considered the formal theory composed of axioms 7-14 and 27-29. Two available relations determine two quotient sets:

1. relation dep determines the quotient set with 3 equivalence classes, which are extensions of categories: $\mathsf{Obj}, \mathsf{Pro}, \mathsf{Soa}$;
2. relation part determines the quotient set with 3 equivalence classes, two of which are extensions of categories: End and Per, and the third is the complement of the union of the other two.

If you take all products of equivalence classes from these sets, you will get 5 sets, which are extensions of $\mathsf{Obj}, \mathsf{Pro}, \mathsf{Soa}, \mathsf{End}$, and Per.

Since the above definition of ontological categories is based on a schema, a set of ontological categories cannot be unique in the sense of Fact 1 or 2. There is, however, a different sense of uniqueness that they exhibit. Let set $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ of ontological categories be called *more fine-grained* than set $\{\mathsf{E}_1, \mathsf{E}_2, \ldots\}$ of ontological categories if for each category D_i there exists category E_j such that $\mathtt{ext}(D_i) \subseteq \mathtt{ext}(E_j)$. Set $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ of categories will be called *most fine-grained* if no set of ontological categories is more fine-grained.

Fact 3. *If* $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ *and* $\{\mathsf{E}_1, \mathsf{E}_2, \ldots\}$ *are most fine-grained sets of ontological categories (with respect to a set of ontological relations), then*

1. *for each category* D_i *there exists category* E_j *such that* $\mathtt{ext}(D_i) = \mathtt{ext}(E_j)$*,*
2. *for each category* E_i *there exists category* D_j *such that* $\mathtt{ext}(E_i) = \mathtt{ext}(D_j)$*.*

Proof. Given the above definition of sets of ontological categories, all most fine-grained sets of ontological categories (with respect to a given set of ontological relations) satisfy the following condition:

$$\forall C \exists x \ \mathtt{ext}(C) = \prod_{i=1}^{n} [x]_{r_i}, \tag{33}$$

where n is, as before, equal to the number of ontological relations. Suppose then that sets $\{\mathsf{D}_1, \mathsf{D}_2, \ldots\}$ and $\{\mathsf{E}_1, \mathsf{E}_2, \ldots\}$ satisfy conditions 33 (and, obviously, 32). Let $\mathsf{D_i}$ and $\mathsf{E_j}$ be two extensionally different categories, i.e., $\mathtt{ext}(\mathsf{D_i}) \neq \mathtt{ext}(\mathsf{E_j})$ such that $\mathtt{ext}(\mathsf{D_i}) \cap \mathtt{ext}(\mathsf{E_j}) \neq \emptyset$ (see the proof of Fact 1). So let x belong to both extensions. By condition 33 this implies that $\mathtt{ext}(\mathsf{D_i}) = \prod_{i=1}^{n} [y]_{r_i}$ and $\mathtt{ext}(\mathsf{D_i}) = \prod_{i=1}^{n} [z]_{r_i}$ overlap on (at least) x. As a result, for each relation r, there exists y and z such that x belongs to $[y]_r$ and $[z]_r$. Then, following the proof Fact 1 we can show that $[y]_r = [z]_r$. Consequently, $\prod_{i=1}^{n} [y]_{r_i} = \prod_{i=1}^{n} [z]_{r_i}$ and $\mathtt{ext}(\mathsf{D_i}) = \mathtt{ext}(\mathsf{E_j})$. □

Finally, let me note that the account defined in this section (schema 31 and condition 32) satisfies all aforementioned formal constraints from (Westerhoff, 2005, p. 22-64).

Ontological relations

Both the general framework and the specific examples clearly indicate that the above account of ontological categories is heavily dependent on ontological relations. It seems that if we are not able to solve the demarcation problem for the latter, the demarcation problem for the former will remain open as well. So, what is an ontological relation, i.e., what is it about ontological relations that separate them from the non-ontological ones?

Before I attempt to elaborate on this issue, let me note that ontological relations are formally less demanding than ontological categories in the sense that the former do not to require all formal constraints specified in (Westerhoff, 2005, p. 22-64). First, the evidence why a set of ontological relations must be hierarchical is much more scarce. In philosophy the ontologist usually employs a certain number of relations (e.g., causation, identity, constitution, parthood, dependence, truth-making, etc.) without worrying whether they can be arranged in a hierarchy or not. In particular he or she is not after the most general relation, similar to the OWL object property `owl:topProperty`. Secondly, the evidence why any two ontological relations must not (properly) overlap is also missing.

Philosophical metaontology seems to neglect the demarcation problem for ontological relations. So a survey of theories of ontological relations, similar to the survey from (Westerhoff, 2005, p. 22-64), still awaits its surveyor. In what follows I will discuss the merits of three recent accounts of relations that, although do not explicitly define ontological relations, *prima facie* are applicable for such a task.

The first account is an exemplification of the modal account of ontological relations. The results from the previous section of this paper, it seems to me, develop the idea of factored ontology put forward by (Simons, 2012, p. 130): "An ontology which explicitly mentions and gives an account of the factors distinguishing the [ontological - PG] categories I call a *factored ontology*." Although P. Simons is sceptical about the prospects of demarcating ontological from non-ontological categories, he lists several relations that can play the role of "the factors distinguishing the categories": dependence, parthood, instantiation, causation, identity. Moreover, probably not being satisfied with a simple list, he points to "their interesting common feature" due to which he names them internal relations:

> A relation R is internal to A and B iff it is essential to A and B jointly that ARB, so that necessarily, if A and B both exist, then ARB. (Simons, 2012, p. 138)

Is such concept suitable for my account of ontological categories?

I think not. By this definition all relations between mathematical or logical entities will be internal relations, including mathematical functions and the like. There are also internal relations outside the domain of *abstracta* that do not look like anything ontological. Think about the relation of having the same spin (value), being a conjugated acid of, or about the phylogenetic relation. So the concept of internal relations is too broad for my purposes. In addition I have doubts whether certain relations in Simons' list are really internal relations. Consider the relation of parthood. Even if this horn is part of that bike (at a certain time), then it does not seem to be necessary that when they both exist (at a certain time), then the horn is part of the bike. It would be if mereological essentialism were true, but a metaontological view, i.e., a theory of ontological relations, shouldn't presuppose a controversial ontological view.

As a matter of fact P. Simons provides another description of internal relations. When the sentence 'A stands in R to B' is true and R is an internal relation, then '[...] we do not need a third thing alongside A and B to act as truthmaker for it, for by the nature of internal relatedness, A and B between them suffice to make it true that ARB' (Simons, 2012, p. 138). Simons clothes this claim in the form of paradox: "Internal relations are actually badly named in my view, because there are no such things (as particulars or universals) as internal relations." (Simons, 2012, p. 138). Still, I do not see how to employ such a view for the demarcation problem at stake.

A similar view on relations can be found in (Guarino, 2009, p. 64-65) – although the terminology is different. N. Guarino defines first the notion of formal relations, which appear to be equivalent to Simons's internal relations, and then refines it with the help of *his* notion of internal relations:

> Within formal relations, I distinguish between the internal and the external ones, depending whether there is an existential dependence relationship between the relata. The basic kinds of internal relationships I have in mind (all formalized in DOLCE) are parthood, constitution, quality inherence, and participation, [...]. (Guarino, 2009, p. 64)

Are internal relations, in Guarino's sense, suitable for being ontological relations? Again I think that the answer is negative. One of the reasons is the same as in the case of Simons's account: there are ontological relations that are not formal relations in Guarino's sense, e.g., parthood. There are parts that are not existentially dependent on the wholes to which they (accidentially) belong and there are wholes that are not existentially dependent on their parts, e.g., bikes and horns. The other reason may be the same as in the case of Simons's account: there *may be* internal relations outside ontology. I annotate this claim with the modal qualification because its validity depend on a particular type of existential dependence in question. For instance, if it is the historic rigid dependence, then the relation of parenthood is an internal relation. If it is the constant rigid dependence, then the relation of causation is not internal despite the fact that it may be taken as a paradigmatic ontological relation. On the other hand, there *may* exist a kind of ontological dependence that picks up most of the usual ontological relations. Finally, Guarino uses a particular ontological relation, which is, by the way, an ontological relation *par excellance*, to define his internal relations. This may be acceptable in a classification of relations, but is problematic as component of a definition of ontological relations. One may ask why distinguish existential dependence over other paradigmatic cases of ontological relations, e.g., identity.

Nonetheless, one may argue that it is possible to inflate the meaning of existential dependence in such a way so that all, or at least most of, paradigmatic cases of ontological relations involve existential dependence. In particular, the inflation in question should make room for parthood, identity, and difference as the genuine cases of existential dependence.

The third account of ontological relations can be based on (Smith and Grenon, 2004). This paper develops an account of formal ontological relations, but the examples of we find there cover most, if not all, of these relations that the ontologists were always interested in. The final version of their definition reads:

> Formal relations are those relations which hold (sometimes *inter alia*) between entities which are constituents of ontologies of different types and which are such that, if they hold between entities of given types, then necessarily all entities of those types enter *mutatis mutandis* into those relations. (Smith and Grenon, 2004, p. 295)

B. Smith and P. Grenon mainly consider two types of ontologies: SPAN and SNAP, i.e., ontologies of endurants and ontologies of perdurants, so for instance the relation of participation that links the former with the latter is a formal ontological relation by the above criterion.

This proposal suffers, in my view, from some minor technical issues with the lack of clarity and certain sloppiness. But even if these problems were overcome, it cannot feed my definitions of ontological categories with the required list of ontological relations. Namely, it seems that the former presupposes the latter, i.e., in order to know which relations are (formal) ontological, you need to which portions of reality are represented by which categories, and this assumes that beforehand you somehow separated the ontological categories from the rest. In short, (Smith and Grenon, 2004) assume that in order to solve the demarcation problem for ontological relations you need to solve the demarcation problem for ontological categories while my analysis implies the inverse dependence.

Taking the failure of the above attempts for granted I would like to go back to the initial idea of ontology as the most general field of study. Namely, I will demarcate ontological relations as the most general relations within a set of relations. Suppose that that a body of knowledge at stake contains a set of binary relations: $\mathsf{r}_1, \mathsf{r}_2, \ldots, \mathsf{r}_\mathsf{n}$. There are two meanings one can attach to the "more/most general" qualification:

1. r is more general$_1$ than r' iff the latter is included in the former, i.e.,
$$\forall x, y[r'(x, y) \to r(x, y)]. \tag{34}$$

2. r is more general$_2$ than r' iff the field of the latter is included in field of the former, i.e.,

$$\forall x, y[r'(x,y) \rightarrow \exists z[r(x,z) \vee r(z,x) \vee r(y,z) \vee r(z,y)]]. \tag{35}$$

The former meaning is stronger than the latter, i.e., if one relation is more general$_1$ than the other, then it is also more general$_2$. Still neither the most general$_2$ relation needs to be most general$_1$ nor *vice versa*.[6] As for the former consider a set containing the relation of identity and the relation of improper parthood. The relation of identity is obviously most general$_2$ (in any set) and in the set in question it is not most general$_1$ because of the improper parthood. As for the latter observation consider the relation of participation, which links, say, substances and processes. If you consider a set of relations in which it is the most general$_1$ relation, then if this set contains the identity relation, then participation will not be most general$_2$ provided that there are other kinds of entities than just substances and processes.

I take these two kinds of generality as characteristic to the aforementioned understanding of ontology. So an *ontological relation* in a set of relations: $\mathsf{r}_1, \mathsf{r}_2, \ldots, \mathsf{r}_\mathsf{n}$ is any member of this set that is either the most general$_1$ or the most general$_2$ relation.

This characteristic is not to be taken as a fully-fledged definition of ontological categories – it is to separate ontological relations from non-ontological in a set of relations. As a result, its epistemic quality depends on the set in question – for instance, if the set includes a gerrymandered relation like the union of the relation of participation, the relation of constitution, and the geometric relation of parallelhood, then this relation may be classified as an ontological relation. Another issue with this characteristic is that it may yield counter-intuitive consequences for some ontological systems. Consider an ontology where the relation of (proper) parthood is not general$_2$, i.e., where there are entities that neither have or are parts, e.g., God. Then in any set of relations that contains both the relation of parthood and the relation of improper parthood the former relation is not ontological in the sense above.

Conclusions

Even if the above attempt at demarcating ontological categories (and the subordinate attempt at demarcating ontological relations) is another failure, I hope that it at least justifies the need for a more insightful understanding of the specificity of ontological research. This need may be less acute in philosophy than in applied ontology, where the proliferation of ontological artefacts appears to have endangered the consistency of this field. To separate it conceptually from other fields we need to make certain distinctions among its basic components: categories and relations. *Ontologiae est distinguere*.

[6]The term "most" refers to the maximal elements with respect to a given relationship, so a relation is most general$_{1,2}$ in a set of relations if there is no more general$_{1,2}$ relation in this set. Consequently, most general relations need not to be unique.

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